AMENDMENTS TO THE SPECIFICATION

IN THE TITLE:

Please amend the title as follows:

--SWITCHING POWER SOURCE CIRCUIT CAPABLE OF TURNING OFF AN "OFF" DRIVE CIRCUIT BEFORE A DRIVE CONTROL SIGNAL BECOMES ACTIVE AND AN ELECTRONIC DEVICE USING THE SAME--

IN THE ABSTRACT:

Please cancel the Abstract of the Disclosure currently of record and replace with the attached new Abstract of the Disclosure.

IN THE SPECIFICATION

Please amend the specification as follows:

On pages 4-13 of the specification, replace the "SUMMARY OF THE INVENTION" with the following "Summary of the Invention":

SUMMARY OF THE INVENTION

Here, in the switching power source circuit, improvement of power source conversion efficiency is one of the most important objects. Recently, with (i) popularization of portable electronic devices which can be driven by a buttery or (ii) enhancement of environmental concerns, the power source conversion efficiency is required to be further improved. However, the switching power source circuit arranged in the foregoing manner cannot sufficiently improve the power

source conversion efficiency, so that there is room for improvement.

The present invention was devised as a result of study on an operational period of an OFF drive circuit required in normally operating a switching power source circuit, and its object is to provide (i) a switching power source circuit whose power source conversion efficiency is high and (ii) an electronic device using the switching power source circuit.

These and other aspects may be realized by providing ~~In order to achieve the foregoing object,~~ the switching power source circuit with ~~(1, 1a) according to the present invention includes:~~ an ON drive circuit for generating an ON drive current which causes a switching element to be turned ON~~,~~. In addition, an OFF drive circuit is provided for generating an OFF drive current which causes the switching element to be turned OFF~~,~~. ~~A~~ A control circuit for controlling both the ON drive circuit and OFF drive circuit, so as to adjust a duty ratio of the switching element so that an output voltage has a predetermined value, is also provided.~~,~~ ~~and an~~ Furthermore, an OFF drive control circuit for causing the OFF drive circuit to begin operating at the same time as an OFF period of the switching element begins, and for causing the OFF drive circuit to stop operating before the OFF period of the switching element ends, is provided.

~~In the foregoing~~ By using the foregoing arrangement, the ON drive circuit preferably generates the ON drive

current in accordance with instructions given by the control circuit, thereby turning ON the switching element. ~~While~~ Furthermore, the OFF drive circuit generates the OFF drive current in accordance with instructions given by the control circuit, thereby turning OFF the switching element. Here, the control circuit controls the ON and OFF drive circuits by adjusting the duty ratio so that the output voltage has a predetermined value ~~in~~ while intermittingly operating the switching element. Thus, the switching power source circuit can steadily supply a predetermined voltage to a load regardless of variation of the input voltage and variation of the load.

Further, the OFF drive control circuit causes the OFF drive circuit to begin operating at the same time as the OFF period of the switching element begins, for example, by shortening the pulse width of the pulse signal (OFF drive control signal) by which the control circuit instructs the OFF drive circuit to operate~~,~~. ~~And~~ In addition, the OFF drive control circuit causes the OFF drive circuit to stop operating before the OFF period of the switching element ends.

~~In the~~ Again, by the foregoing arrangement, the OFF drive circuit can operate~~s~~ at the same time as when the OFF period of the switching element begins, so that it is possible to turn OFF the switching element without any trouble. Further, the OFF drive circuit stops operating before the OFF period of the switching element ends, so that it is possible to reduce an average value of the OFF

drive current. ~~And~~ It is also possible with the present arrangement to reduce power consumption as compared with a case where the OFF drive circuit continues to operate during the OFF period. Note that, ~~while~~ when the OFF drive circuit stops operating, the OFF drive current is not generated~~,~~. ~~But~~ Furthermore, the switching element ~~has already been~~ is shut down while the OFF drive circuit ~~has been~~ is being ~~operating~~ operated, so that ~~the~~ it is possible to continue to shout down the switching element without any trouble during rest of the OFF period, that is, until the ON drive circuit begins operating again.

As a result, it is possible to realize a switching power source circuit whose power source conversion efficiency is high compared with an arrangement in which the OFF drive circuit continues to operate during the OFF period of the switching element.

Further, in addition to the foregoing arrangement, another aspect of the present invention includes an arrangement whereby ~~it may be so arranged that:~~ the OFF drive circuit includes~~:~~ a constant current source, ~~,~~ and a current mirror circuit for generating, as the OFF drive current, a current which is interrelated with a current outputted by the constant current source, so as to supply thus generated current to a control terminal of the switching element, or so as to draw thus generated current from the control terminal. ~~,~~ ~~and a~~ A stopping circuit is also provided for causing the constant current source to stop outputting the current while the OFF drive controlling circuit indicates stoppage of operation.

In the above noted arrangement, the current mirror circuit is preferably used to supply the OFF drive current to the control terminal of the switching element, or to draw the OFF drive current from the control terminal. ~~, and the~~ The OFF drive circuit can ~~includes~~ include not only a current path allowing the OFF drive current to flow but also a current path allowing a current outputted by the constant current source to flow. Thus, when the OFF drive circuit continues to operate during the OFF period of the switching element, the OFF drive circuit consumes not only the OFF drive current but also the current outputted by the constant current source. However, according to the foregoing arrangement, the stopping circuit is provided, and causes the constant current source to stop supplying the current while the OFF drive control circuit instructs the OFF drive circuit to stop operating. As a result, it is possible to realize ~~the~~ a switching power source circuit whose power source conversion efficiency is high due in part to ~~though~~ the current mirror circuit that is being provided.

Further, in addition to the foregoing arrangement, in still another aspect of the present invention, it may be so arranged that~~:~~ the OFF drive circuit includes~~:~~ a constant current source~~,~~ a current mirror circuit for outputting a current which is interrelated with a current outputted by the constant current source~~,~~ a current amplifying circuit for amplifying, as the OFF drive current, the current outputted by the current mirror circuit, so as to supply thus amplified current to a

control terminal of the switching element, or so as to draw thus amplified current from the control terminal,~~:~~ and a stopping circuit for causing the constant current source to stop outputting the current while the OFF drive controlling means instructs the OFF drive circuit to stop operating.

As in the aforementioned arrangement having the stopping circuit, ~~the~~ this arrangement is such that~~:~~ the stopping circuit is provided, and the stopping circuit causes the constant current source to stop supplying the current while the OFF drive control circuit instructs the OFF drive circuit to stop operating. Thus, it is possible to realize ~~the~~ a switching power source circuit whose power source conversion efficiency is high due in part to ~~though~~ the current mirror circuit ~~is~~ being provided. Further, in the foregoing arrangement, the current amplifying circuit is provided, so that it is possible to increase an amount of the current which is supplied to the control terminal of the switching element or drawn from the control terminal. As a result, it is possible to reduce a storage time and a drop time of the switching element compared with a case where the current amplifying circuit is not provided, thereby further improving the power source conversion efficiency.

Further, in addition to the foregoing arrangement, in yet another aspect of the present invention, it may be so arranged that~~:~~ the OFF drive controlling circuit outputs a duty limit signal for determining an upper limit of the duty ratio of the switching element.~~,~~ ~~and~~ In

such a case, the duty limit signal is set so that the OFF period of the switching element is longer than an operational period of the OFF drive circuit ~~in a case where~~ when the duty ratio has an upper limit value.

In the foregoing arrangement, by setting the pulse width, ~~or in a similar manner~~ for example, the duty limit signal is set so that the OFF period of the switching element, ~~in the case where~~ when the duty ratio has the upper limit value, is longer than the operational period of the OFF drive circuit. Thus, the operational period of the OFF drive circuit is ordinarily shorter than the OFF period of the switching element regardless of conditions of the input voltage and the load.

Further, the OFF drive circuit can ~~controls~~ the operational period of the OFF drive circuit, and can ~~generates~~ the duty limit signal. Thus, unlike an arrangement in which a circuit provided separately from the OFF drive circuit is responsible for generating ~~generates~~ the duty limit signal~~, for example,~~ even when the operational period of the OFF drive circuit has a value~~,~~ which deviates from a designed value~~,~~ due to manufacturing unevenness and variation of ambient temperature, ~~also~~ the OFF period of the switching element, in the case where the duty ratio has the upper limit value, also has a value which deviates from a designed value in ~~the~~ a similar manner.

As a result, the operational period of the OFF drive circuit can be made shorter than the OFF period of the switching element, so that it is possible to set the

operational period of the OFF drive circuit so as not to overlap with the ON period of the switching element. Thus, even when the duty ratio has the upper limit value, it is possible to realize the switching power source circuit which can surely turn OFF the switching element and has high power source conversion efficiency.

Further, in addition to the foregoing arrangement, another aspect of the present invention has ~~it may be so~~ an arranged ~~that:~~ whereby the OFF drive controlling circuit includes~~:~~ a reference constant current source for generating a reference constant current~~,~~ a constant current generating current mirror circuit for generating a first constant current and a second constant current each of which is interrelated with the reference constant current outputted by the reference constant current source~~,~~ a first pulse generating circuit for determining a pulse width of the OFF drive control signal indicative of the operational period of the OFF drive circuit in accordance with the first constant current~~,~~ and a second pulse generating circuit for determining a pulse width of the duty limit signal in accordance with the second constant current.

In the foregoing arrangement, the first pulse generating circuit for determining the pulse width of the OFF drive control signal and the second pulse generating circuit for determining the pulse width of the duty limit signal respectively determine the pulse widths in accordance with constant currents (first or second constant current) each of which is interrelated with the

constant current generated by the reference constant current source. Thus, for example, even when the operational period of the OFF drive circuit has a value, which deviates from a designed value, due to manufacturing unevenness and variation of ambient temperature, ~~also~~ the OFF period of the switching element, in the case where the duty ratio has the upper limit value, also has a value which deviates from a designed value in ~~the~~ a similar manner. As a result, even when the duty ratio has the upper limit value, it is possible to realize the switching power source circuit which can surely turn OFF the switching element and has high power source conversion efficiency.

Further, ~~the~~ an electronic device according to the present invention includes any one of the switching power source circuits arranged in the above noted foregoing manners. Thus, it is possible to realize ~~the~~ an electronic device which can consume~~s~~ less power.

For a fuller understanding of the nature and advantages of the invention, reference should be made to the ensuing detailed description taken in conjunction with the accompanying drawings.